Low thicket communities of rocky outcrops in the northern Orange Free State

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A phytosociological analysis of the low thicket vegetation of the rocky outcrops of the Heilbron–Lindley–Warden–Villiers area (northern Orange Free State) was conducted. Relevés were compiled in 67 stratified random sample plots. A TWINSPAN classification, refined by Braun-Blanquet procedures, revealed eight distinct plant communities. A hierarchical classification, description, plant-ecological interpretation and ordination of the plant communities are presented.

'n Fitososiologiese analise van die struikruigtes van die rotsagtige dagsome van die Heilbron–Lindley–Warden–Villiers gebied (noordelike Oranje-Vrystaat) is onderneem. Relevés is in 67 gestratifiseerde ewekansig gekose monsterpersele saamgestel. 'n TWINSPAN-klassifikasie, verfyn deur Braun-Blanquet-prosedures, het agt duidelik onderskeibare plantgemeenskappe aangetoon. 'n Hiërargiese klassifikasie, beskrywing, plantekologiese interpretasie en ordening van die plantgemeenskappe word aangebied.

Keywords: Braun-Blanquet classification, Grassland Biome, plant communities, southern Africa, synecology.

Introduction

The necessity of detailed plant-ecological studies as a basis for sound land-use planning, management and research, is widely recognized (Pentz 1938; Codd 1949; Bayer 1970; Foran *et al.* 1986; Bosch *et al.* 1987). As part of the vegetation mapping and phytosociological synthesis of the western Grassland Biome (Scheepers 1986), this study aims to identify, classify, describe and ecologically interpret the little-known vegetation of the northern Orange Free State.

The natural vegetation of this area is clearly adversely affected by the past and existing farming practices. Furthermore, there are presently no proclaimed or formal conservation areas in this part of the Grassland Biome. A detailed classification and description of the plant communities within this area is therefore of the utmost importance, not only as a basis for ecologically sound forage resource management, but also for the identification of suitable conservation areas, thereby ensuring the future preservation of the different ecosystems encountered in the area.

A broad description of the physical environment and major plant communities of the Heilbron–Lindley–Warden–Villiers area of the northern Orange Free State was presented by Fuls *et al.* (1993). Subsequently, a more detailed analysis of the respective major plant communities has been undertaken. This paper specifically reports on the detailed Braun-Blanquet classification and plant-ecological interpretation of the low thicket communities associated with the rocky outcrops of the study area.

Study area

The study area lies within the western climatic climax Grassland Biome of southern Africa and is situated between 27°45′ and 29°00′E longitude and 27°00′ and 28°00′S latitude (Figure 1). The area covers approximately 1 000 000 ha and lies between 1500 and 1800 m above sea-level. The study area forms part of the Highveld inland plateau and consists predominantly of smoothly plained or gently rolling land surfaces of the miocene age (Mentis & Huntley 1982). The topography comprises a mosaic of flat to undulating terrain types. Isolated hills and ridges are encountered occasionally in the northern part, and more frequently in the southern part. The low thicket vegetation of the rocky outcrops is restricted to the steeper slopes

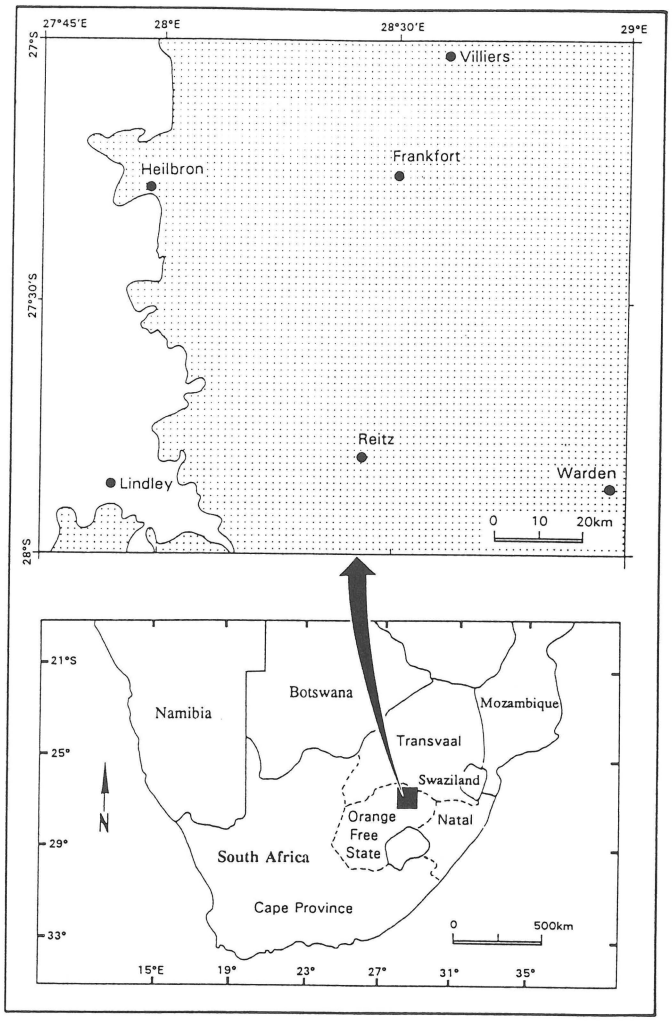

Figure 1 The study area in which the low thicket plant communities of the rocky outcrops were analysed.

(mostly > 30°), covering less than 5% of the total study area. The rocky outcrops consist predominantly of dolerite, with sandstone ridges being encountered occasionally. However, the surface rocks may comprise a combination of dolerite and sandstone with mudstone and/or shale sometimes present (see also Fuls *et al.* 1993).

Methods

Relevés were compiled in 67 stratified random sample plots. Care was taken to restrict sample plots to vegetation in pristine condition whenever possible. Severely degraded stands were avoided. Stratification was based on topographical position (crest, plateau or slope), aspect and geology. Plot sizes were approximately 10 m × 10 m (Scheepers 1975). In each sample plot, all species were recorded and their respective canopy cover values and/or abundance recorded, according to the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). Taxa names conform to those of Gibbs Russell *et al.* (1985, 1987). Environmental data recorded include geology, topographical position, soil type and depth, soil texture, aspect, slope, rockiness of the soil surface, erosion, soil crusting/compaction and utilization by herbivores.

Two-way indicator species analysis (TWINSPAN) (Hill 1979a) was applied to the floristic data set in order to derive a first approximation of the plant communities of the area. Bredenkamp *et al.* (1991) found that TWINSPAN was useful as a first classification. Refinement of the TWINSPAN classification was done by the application of Braun-Blanquet procedures (see also Bredenkamp *et al.* 1989; Kooij *et al.* 1990). From the final phytosociological table, eight plant communities were identified.

In order to determine and statistically quantify possible vegetation gradients, Detrended Correspondence Analysis (DECORANA) (Hill 1979b) was applied to the floristic data set.

Structural classifications of the different plant communities are in accordance with Edwards (1983).

Results and Discussion

The low thicket vegetation was divided into eight plant communities. A hierarchical classification and associated ecologic interpretation of the respective plant communities are presented in Figure 2.

The low thicket vegetation of the rocky outcrops is species-rich, containing a variety of trees, shrubs, herbs and forbs. As many as 269 species (67 relevés), out of a total of 453 species encountered in the entire study area (263 relevés), were found in low thicket communities. On average, 35 species were recorded per sample plot.

Despite the presence of various shrubs and trees, grass species such as *Eragrostis curvula, Cymbopogon plurinodis, Themeda triandra* (species group V), *Elionurus muticus, Aristida junciformis* (species group U), *Harpochloa falx* (species group T), *Koeleria capensis, Andropogon appendiculatus* (species group S) and *Hyparrhenia hirta* (species group H), are often conspicuously more abundant than woody species within the low thicket communities (Table 1). Collectively, the canopy cover of these graminoids often exceeds 60% of the total canopy cover. However, a single graminoid was seldom found to be clearly and exclusively dominant. The graminoid *Ehrharta erecta* is also often encountered in all plant communities (species group V, Table 1), but, owing to its preference for disturbed, moist and shaded areas, this species does not tend to be overall dominant in low thicket communities.

Trees encountered in the area are generally less than 4 m tall, whereas the shrubs are mostly less than 2 m tall, the only occasional exceptions being *Diospyros lycioides* (species group J) and *Ehretia rigida* (species group C) (Table 1). Trees and shrubs often occur in patch-like clusters on steep slopes, interspaced by tracts where grass species dominate. Only occasionally do the woody strata make up more than 50% of the total canopy cover on the steep slopes. Many tree and shrub species apparently co-exist habitually. Examples of species often found in combination include the trees *Celtis africana* (species group I), *Kiggelaria africana, Rhus pyroides* (species group P) and *Heteromorpha trifoliata* (species group U), and the shrubs *Diospyros lycioides, Protasparagus laricinus* (species group J), *P. setaceus* (species group K), *Grewia occidentalis* (species group I) and *Diospyros austro-africana* (species group T) (Table 1). The establishment of one woody species probably creates a more favourable niche for other woody species to follow suit. Steep, cliff-like areas on the slopes are often dominated by woody vegetation. Individual tree and shrub species were seldom found to be dominant, the only occasional exceptions being the medium to large (1 – 3 m), evergreen shrub *Diospyros lycioides* (species group J) on the drier northerly facing slopes, and the small to medium (0.7 – 1.5 m), semi-woody shrub *Artemisia afra* (species group V) on the wetter southerly facing slopes (Table 1).

The distribution pattern of the low thicket vegetation apparently depends primarily on variations in irradiation. Variations in moisture and micro-climate are related to differences in irradiation due to different aspects and gradients.

Generally, the drier, northerly facing slopes were found to be severely utilized by livestock. Severe patch-like overutilization by rock dassies (*Procavia capensis*) was more evident on the southerly facing slopes. The obvious and unchecked preferential utilization of these areas by livestock as well as the damage done by rock dassies, often occurring in large numbers (probably due to the extinction of their natural predators from the area), seriously threaten the future preservation of the plant communities and ecosystems of the rocky outcrops.

There are no woody species which are present in all communities. Trees frequently encountered in most plant communities include *Heteromorpha trifoliata* (species group U), *Kiggelaria africana, Rhus pyroides* (species group P) and *Celtis africana* (species group I) (Table 1). Shrubs occurring in most plant communities include *Artemisia afra* (species group V), *Diospyros austro-africana, Rhus dentata* (species group T), *Diospyros lycioides* and *Protasparagus laricinus* (species group J) (Table 1).

Forb species that often occur in all low thicket communities are *Crassula lanceolata, Commelina africana* and *Archyranthes aspera* (species group V, Table 1). Common ferns are *Mohria caffrorum* (species group V), *Cheilanthes eckloniana* (species group U) and *C. virides* (species group P) (Table 1).

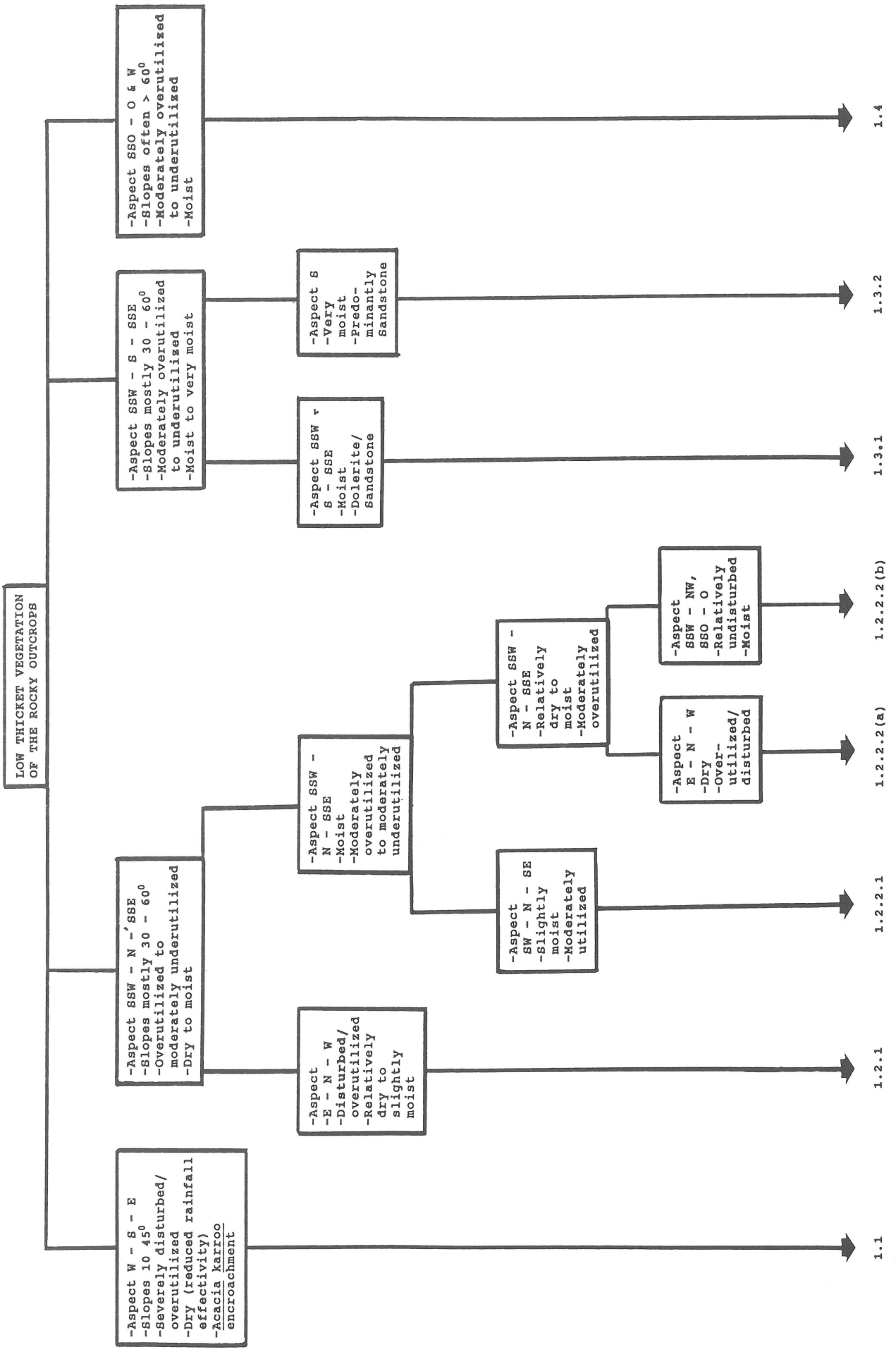

Figure 2 The hierarchical classification and associated ecological characteristics of the different plant communities. Numbers of communities correspond with descriptions in text.

Table 1 Phytosociological table of the low thicket communities of the northern Orange Free State

| Community number | 1 | | |

Table 1 Continued

| Community number | 1 | | |

Classification

The low thicket vegetation of the rocky outcrops of the study area is classified as a *Mohria caffrorum – Heteromorpha trifoliata* Low Thicket (see also Fuls *et al.* 1993). The hierarchical classification of the eight plant communities is as follows:

1 *Mohria caffrorum – Heteromorpha trifoliata* Low Thicket
- 1.1 *Eustachys paspaloides – Acacia karroo* Low Thicket of the Vegkop area
- 1.2 *Hyparrhenia hirta – Celtis africana* Low Thicket
  - 1.2.1 *Hyparrhenia hirta – Grewia occidentalis* Low Thicket of the dry, northerly facing slopes
  - 1.2.2 *Hyparrhenia hirta – Lantana rugosa* Low Thicket of the slightly moist to moist slopes
    - 1.2.2.1 *Setaria nigrirostris – Lantana rugosa* Low Thicket
    - 1.2.2.2 *Aristida diffusa – Melinis nerviglumis* Low Thicket
      - 1.2.2.2(a) *Aristida canescens – Solanum panduriforme* Variant
      - 1.2.2.2(b) *Melinis nerviglumis – Rhus pyroides* Variant
- 1.3 *Helictotrichon turgidulum – Harpochloa falx* Low Thicket
  - 1.3.1 *Vernonia natalensis – Koeleria capensis* Low Thicket of the moist, southerly facing slopes
  - 1.3.2 *Harpochloa falx – Rubus ludwigii* Low Thicket of the very moist and cool southern slopes
- 1.4 *Arundinella nepalensis – Leucosidea sericea* Low Thicket of the cliff-like stream-banks of the Wilge River

Description of the communities

1.1 *Eustachys paspaloides – Acacia karroo* Low Thicket

Diagnostic species group A; type relevé: 262

This plant community was found to be restricted to the Vegkop area (27°28'S; 27°55'E), comprising only a few hectares. Surface rocks are predominantly doleritic. The vegetation was overutilized to such an extent that the herbaceous layer was totally destroyed in many places. Severe *Acacia karroo* encroachment is evident throughout. This small to medium-sized tree is conspicuously diagnostic (species group A, Table 1). Other diagnostic species are the perennial, tufted (sometimes rhizomatous) graminoid *Eustachys paspaloides*, the small shrubs *Waltheria indica* (being indicative of disturbance/retrogression) and *Teucrium trifidum*, as well as the succulent *Kalanchoe rotundifolia*, often found underneath trees and larger shrubs (species group A, Table 1).

Conspicuous tree species often encountered, but without diagnostic value, are the small to medium-sized (2 – 5 m), deciduous *Celtis africana* (species group I) and evergreen *Euclea crispa* (species group J) (Table 1). The small to large, perennial, tufted graminoid *Eragrostis curvula* is the only dominant grass species (species group V, Table 1). Non-diagnostic species include the shrubs *Ehretia rigida* (species group C), *Diospyros lycioides* and *Protasparagus laricinus* (species group J), and the forbs *Hemizygia pretoriae* (species group J) and *Crassula lanceolata* (species group V) (Table 1). The large, exotic, succulent encroacher *Opuntia ficus-indica*, being often indicative of disturbance and degradation, was also found (species group C, Table 1). A low species diversity of 22 species per sample plot was recorded, owing to the severe degradation of the vegetation.

Although this plant community has a very restricted distribution and is markedly different from other communities encountered in this study area, it is regarded as a mere relict (albeit severely retrogressed) of a similar plant community, the *Eustachys paspaloidis – Maytenion heterophyllae*, encountered to the west of the study area (see Fuls *et al.* 1992).

1.2 *Hyparrhenia hirta – Celtis africana* Low Thicket

Diagnostic species group H; type relevé: 21.

This plant community is encountered on the dry or slightly moist, steep slopes (mostly 30 – 60°). The slopes are mostly dry and warm due to the high solar radiation associated with northerly facing slopes. The aspect is predominantly west, north or east. However, slopes facing south-west to south-south-west and south-east to south-south-east were occasionally found to be covered by this low thicket. Surface rocks were mostly doleritic, with sandstone sometimes present.

Diagnostic woody species are absent. Trees frequently found within this low thicket are *Celtis africana* (3 – 6 m) (species group I), the small to medium-small (2 – 4 m), evergreen *Rhus pyroides* (species group P) and the small (1.5 – 3 m), deciduous *Heteromorpha trifoliata* (species group U) (Table 1). Shrubs often encountered are *Grewia occidentalis* (species group I), *Diospyros lycioides*, *Protasparagus laricinus* (species group J), *P. setaceus* and *Rhus rigida* (species group K) (Table 1).

Hyparrhenia hirta, a large, tufted perennial, is the most conspicuous diagnostic graminoid, sometimes being strongly dominant (species group H, Table 1). Other diagnostic graminoids often found in this plant community are the medium-sized, perennial, tufted *Heteropogon contortus*, the rhizomatous, loosely tufted, medium-sized, perennial *Setaria nigrirostris* and the annual or biannual, small, tufted *Aristida congesta* subsp. *congesta* (species group H, Table 1).

Diagnostic forbs are *Bidens bipinnata*, characteristically associated with disturbed areas underneath trees and larger shrubs, and *Pollichia campestris* (species group H, Table 1). The xeric fern *Pellaea calomelanos* is also diagnostic (species group H, Table 1).

1.2.1 *Hyparrhenia hirta – Grewia occidentalis* Low Thicket

Diagnostic species group B; type relevé: 27.

This plant community is restricted to clearly disturbed (at least in patches), dry, northerly facing slopes. The only exclusively diagnostic species are the shrub (appearing forb-like) *Pavonia burchellii*, characteristically encountered in disturbed, rocky patches underneath the larger trees and shrubs, and the medium-small, tufted, perennial graminoid *Enneapogon scoparius* (species group B, Table 1). This grass species thrives on dry, disturbed, rocky slopes, occasionally becoming dominant (species group B, Table 1).

Although not diagnostic, the wiry, perennial, tufted graminoid *Aristida canescens* is often present, generally being indicative of retrogression on well-drained, shallow, rocky soils (species group E, Table 1). The presence of the exotic succulent *Opuntia ficus-indica* (species group C, Table 1) is also indicative of the disturbance within this plant community.

No diagnostic trees or large shrubs were found. However, *Celtis africana* has a characteristically high constancy (species group I, Table 1). The deciduous, medium to large shrub (1.5 – 3 m) *Ehretia rigida* is restricted to this plant community and the *Eustachys paspaloides – Acacia karroo* Low Thicket (species group C, Table 1). On average, 28 species per sample plot were recorded.

1.2.2 *Hyparrhenia hirta – Lantana rugosa* Low Thicket

Diagnostic species group G; type relevé: 195.

This plant community is associated with slightly moist to moist slopes facing south-south-west to north to south-south-east, being generally more moist and less degraded than the *Eustachys paspaloides – Acacia karroo* and *Pavonia burchellii – Celtis africana* Low Thickets.

Lantana rugusa, a small, evergreen shrub, is the only diagnostic woody species (species group G, Table 1). Other woody species, e.g. *Diospyros lycioides* (species group J), *Rhus pyroides* (species group P), the small (< 1 m), often decumbent, evergreen shrub *R. rigida* (species group K), the small to medium-sized, deciduous shrub *R. dentata* (species group T), and the small, evergreen shrub *Diospyros austro-africana* (species group T), are not restricted to this plant community (Table 1).

The only diagnostic graminoid is the mostly small, tufted, perennial *Eragrostis racemosa* (species group G, Table 1). Diagnostic forbs are *Hermannia depressa, Conyza podocephala, Argyrolobium pauciflorum* and *Crabbea acaulis* (species group G, Table 1).

Species often encountered in this plant community, but absent from plant communities 1.1 and 1.2.1, include the small to medium-sized (2 – 4 m), evergreen tree species *Kiggelaria africana* and *Rhus pyroides* (species group P), the tufted, perennial graminoids *Trachypogon spicatus* (species group P) and *Harpochloa falx*, and the forbs *Senecio hastatus, Berkheya radula* (species group P), *Salvia repens* and *Hibiscus aethiopicus* (species group T) (Table 1).

1.2.2.1 *Setaria nigrirostris – Lantana rugosa* Low Thicket

Diagnostic species group D; type relevé: 68.

This plant community is encountered on the slightly moist, moderately utilized slopes. Slope aspect varies from south-west to north to south-east.

Generally speaking, trees and shrubs are relatively inconspicuous, being mostly small, infrequently encountered and/or widely dispersed, contributing little to the overall canopy cover. Noteworthy is the general absence of woody species such as *Euclea crispa, Protasparagus laricinus* (species group J), *P. setaceus, Rhus rigida* (species group K) and *Heteromorpha trifoliata* (species group U, Table 1). It appears as if the moderate utilization and dominance of the large tufted graminoid *Hyparrhenia hirta* (species group H) restrict the widespread establishment of woody species.

There are no clear diagnostic species for this plant community, and it is rather characterized by the absence of species listed in species groups E, F and L (Table 1). Slightly diagnostic species are the erect forbs *Oenothera stricta* and *Silene burchellii* and mat-forming, decumbent *Arctotis arctotoides* (species group D, Table 1). On average, 34 species per sample plot were recorded.

1.2.2.2 *Aristida diffusa – Melinis nerviglumis* Low Thicket

Diagnostic species group F; type relevé: 24.

This plant community is associated with moderately overutilized, dry to moist slopes facing south-south-west to north to south-south-east. *Aristida diffusa*, a medium-sized, wiry, tufted, perennial graminoid, and the small, densely tufted (sometimes forming small, mat-like patches), weak perennial graminoid *Microchloa caffra* are the only diagnostic species (species group F, Table 1). The medium-small, loosely tufted (occasionally being rhizomatous) perennial grass species *Brachiaria serrata* (species group L) is also regarded as mildly diagnostic (Table 1).

The small (1.5 – 3 m), deciduous, tree species *Maytenus heterophylla*, the small, scantly branched, deciduous shrub *Rhus discolor*, the large creeper *Clematis brachiaria*, the shrub *Leonotis dysophylla* (often forb-like in appearance) and the forb *Helichrysum nudifolium* are characteristically found in this community (species group L, Table 1). These species are mostly absent in plant communities 1:1, 1.2.1 and 1.2.2.1.

Two variants were distinguished within this plant community:

1.2.2.2(a) *Aristida canescens – Solanum panduriforme* Variant

Diagnostic species group E; type relevé: 10.

This variant occurs on dry to slightly moist, moderately overutilized slopes facing west to north to east.

All large woody species within this variant also occur in other plant communities, but *Diospyros lycioides* (species group J) often has a characteristically high frequency and canopy cover within this variant (Table 1). The diagnostic, small, weedy shrub *Solanum panduriforme*, characteristically associated with disturbed areas, has a notably high constancy (species group E, Table 1). Other small shrubs which are mildly diagnostic are the densely branched, foliose *Indigofera hedyantha*, the mostly decumbent *Rhynchosia adenodes* as well as the thorny *Ziziphus zeyheriana*, often occurring as small, patch-like, dense stands in retrogressed areas (species group E, Table 1).

Aristida canescens and the small, annual, loosely tufted, pioneer species *Tragus berteronianus* are the only diagnostic graminoid species (species group F, Table 1).

Diagnostic forbs encountered in this plant community are *Vernonia oligocephala, Helichrysum rugulosum, Thesium* sp., *Berkheya pinnatifida* and *Solanum retroflexum* (species group E, Table 1). The particular species and number of shrubs and forbs, as well as the diagnostic grass species, are all indicative of the disturbance/retrogression within this variant. On average, 38 species per sample plot were recorded.

1.2.2.2(b) *Melinis nervigiumis – Rhus pyroides* Variant

Type relevé: 24.

This variant is not characterized by a specific species group, but is rather characterized by the absence of diagnostic species of the *Aristida canescens – A. diffusa* Variant (species group E, Table 1). Secondly, graminoids occurring generally in this variant, such as *Koeleria capensis, Andropogon appendiculatus* and *Tristachya leucothrix* (species group S) are mostly absent from previously described plant communities [1.1, 1.2.1, 1.2.2.1 and 1.2.2.2(a)] (Table 1).

This variant is associated with moderately utilized, moist slopes facing south-south-west to north-west and south-south-east to east. These slopes are generally less insolated than those associated with previously described plant communities [1.1, 1.2.1, 1.2.2.1 and 1.2.2.2(a)] and are therefore cooler and more moist.

Graminoids with a noteworthy high constancy and/or cover are *Melinis nerviglumis* (species group K), *Trachypogon spicatus* (species group P), *Elionurus muticus* (species group U) and *Cymbopogon plurinodis* (species group T) (Table 1). *Harpochloa falx* (species group T) is also encountered more often in this variant than in the *Aristida canescens – A. diffusa* Variant. On average, 41 species per sample plot were recorded.

1.3 *Helictotrichon turgidulum – Harpochloa falx* Low Thicket

Diagnostic species group O; type relevé: 140.

This plant community is encountered on the moderately utilized to moderately overutilized, moist to very moist, steep slopes (mostly 30 – 60°) facing south-south-west to south to south-south-east. Patches are severely utilized/disturbed by rock dassies, particularly underneath trees and in shaded areas adjacent to large boulders.

Diagnostic tree species are absent from this plant community; however, the widely distributed *Kiggelaria africana* has a characteristically high presence and canopy cover (species group P, Table 1). *Heteromorpha trifoliata* is also often encountered (species group U, Table 1). Noteworthy is the general absense of *Celtis africana* and the shrub *Grewia occidentalis* (species group I, Table 1).

Artemisia afra (species group V), *Diospyros austro-africana* and *Rhus dentata* (species group T) are the only shrubs frequently encountered in this plant community (Table 1).

The medium to large, tufted, perennial graminoids *Helictotrichon turgidulum* and *Pennisetum sphacelatum* are diagnostic, as well as the forb *Cineraria alchemilloides* (species group O, Table 1). Other graminoids with a characteristically high abundance and/or cover include *Koeleria capensis* (species group S), *Harpochloa falx* (species group T) and *Ehrharta erecta* (species group V) (Table 1).

This plant community does not have diagnostic forb species, but forbs such as *Senecio hastatus, Dianthus mooiensis* (species group P) and *Salvia repens* (species group T) as well as the mesic fern *Mohria caffrorum* and the small, succulent *Crassula lanceolata* are frequently encountered (species group V, Table 1).

1.3.1 *Vernonia natalensis – Koeleria capensis* Low Thicket

Diagnostic species group M; type relevé: 229.

This plant community is associated with the moderately utilized, moist slopes facing south-south-west to south to south-south-east.

Diagnostic species are the shrublike forb *Vernonia natalensis*, the decumbent forb *Argyrolobium tysonii* and the small, erect, foliose shrub *Myrsine africana* (species group M, Table 1).

Tree species often encountered are *Euclea crispa* (species group J), *Maytenus heterophylla* (species group L), *Kiggelaria africana, Rhus pyroides* (species group P) and *Heteromorpha trifoliata* (species group U) (Table 1). Shrubs frequently found include the cladophyllous *Protasparagus laricinus* (species group T), *Rhus discolor*, having all characteristically high abundance in this plant community, and *Rhus rigida* (species group L) (Table 1).

Grass species with a characteristically high abundance are *Koeleria capensis* (species group S) and *Harpochloa falx* (species group T) (Table 1). The forb *Senecio hastatus*, being primarily associated with moist, shaded, slightly disturbed areas, has a noteworthy high abundance (species group P, Table 1). On average, 36 species per sample plot were recorded.

1.3.2 *Harpochloa falx – Rubus ludwigii* Low Thicket

Diagnostic species group N; type relevé: 100.

This plant community is encountered on moderately utilized to moderately overutilized, very moist and cool south-facing slopes. Although dolerite may be present, these slopes consist predominantly of sandstone ridges, often being cliff-like, with large sandstone boulders. The slopes are particularly moist owing to the shading by the cliffs and/or large boulders and the southern aspect.

The only diagnostic woody species is the small, sparsely branched, thorny, often pendent shrub *Rubus ludwigii* (species group N, Table 1). Noteworthy is the absence of woody species listed in species groups J – L (Table 1). This low thicket does not have a dominant or conspicuous woody component, both in terms of the number of species and the number of individuals encountered, being rather dominated by a combination of tufted, perennial grass species. These include *Koeleria capensis, Andropogon appendiculatus, Tristachya leucothrix*, the latter two having a noteworthy high constancy and/or canopy cover (species group S), *Harpochloa falx* (species group T), *Aristida junciformis*, also being particularly abundant (species group U), and *Eragrostis curvula* (species group V) (Table 1).

Diagnostic grass species are the medium-sized, loosely tufted, short-lived perennial or annual *Bromus catharticus* and the diminutive, stoloniferous, mat-forming perennial *Cynodon hirsutus* (species group N, Table 1). Both these graminoids are characteristically associated with moist, shaded, disturbed areas.

Forb species which are diagnostic include *Galium thunbergianum, Helichrysum cephaloideum, Oxalis obliquitera, Nemesia albiflora* and *Phytolacca heptandra. The fern Asplenium aethiopicum* as well as the exotic, parasitic *Cuscuta campestris* are also frequently encountered (species

group N, Table 1). On average, 41 species per sample plot were recorded.

1.4 *Arundinella nepalensis – Leucosidea sericea* Low Thicket of the cliff-like stream-banks of the Wilge River

Diagnostic species group Q; type relevé: 255.

This plant community is restricted to the steep (often >60°), cliff-like stream-banks of the Wilge River. The slopes face west or south to east and are mostly moist.

Leucosidea sericea, a small (1.5 – 3 m), shrub-like, evergreen tree species, is conspicuous and diagnostic for this plant community (species group Q, Table 1). Other woody species encountered are *Heteromorpha trifoliata* (species group U) and the shrub or small tree species *Rhus dentata* (species group T) and the small, evergreen shrub *Clutia affinis* (species group R) (Table 1).

Diagnostic grass species are the large, tufted, perennials *Arundinella nepalensis*, sometimes becoming dominant, and *Hyparrhenia dregeana* (species group Q, Table 1). The rhyzomatous, sward-forming *Imperata cylindrica* was also encountered occasionally at the footslopes of the cliff-like stream-banks. Noteworthy is the scarcity, or absence, of *Eragrostis curvula* from this plant community (species group V, Table 1).

Forbs with diagnostic value include *Pelargonium ranunculophyllum* and *Zantedeschia albomaculata* (species group Q, Table 1). On average, 26 species per sample plot were recorded.

Ordination

The distribution of relevés along the first and second axes of the ordination is presented in Figure 3. A distinct discontinuity in the distribution of the plant communities can be observed. The plant communities are generally restricted to specific areas in the scatter diagram.

The distribution of the relevés gives an indication of the affinities between plant communities 1.2.2.2(a), 1.2.2.2(b), 1.3.1 and 1.3.2, both with regard to species composition (see Table 1) and habitat (Figure 3). The conformity between plant communities 1.2.2.1 and 1.2.2.2(a) is also illustrated. The large discontinuity of relevés of plant community 1.2.1 is ascribed to habitat and forage utilization variations between relevés grouped in this plant community. Similarly, there are substantial variations in occurrence and abundance of plant species recorded within the different relevés of this community, i.e. relevés 25 and 253 have a distinctly lower abundance of *Hyparrhenia hirta* than other relevés in this plant community, whereas relevés 231 and 232 have a particularly high canopy cover of *Enneapogon scoparius* (Table 1).

Within plant community 1.4, the large discontinuity between relevés 87, 88 and 255 on the one hand, and relevés 84, 85 and 93 on the other, is also reflected in the habitat and species associated with the two distinctive relevé clusters. Despite the obvious variation, it was decided to group these relevés into one plant community. The cluster on the right-hand side of the figure is associated with less steep, underutilized slopes with smaller boulders (not being

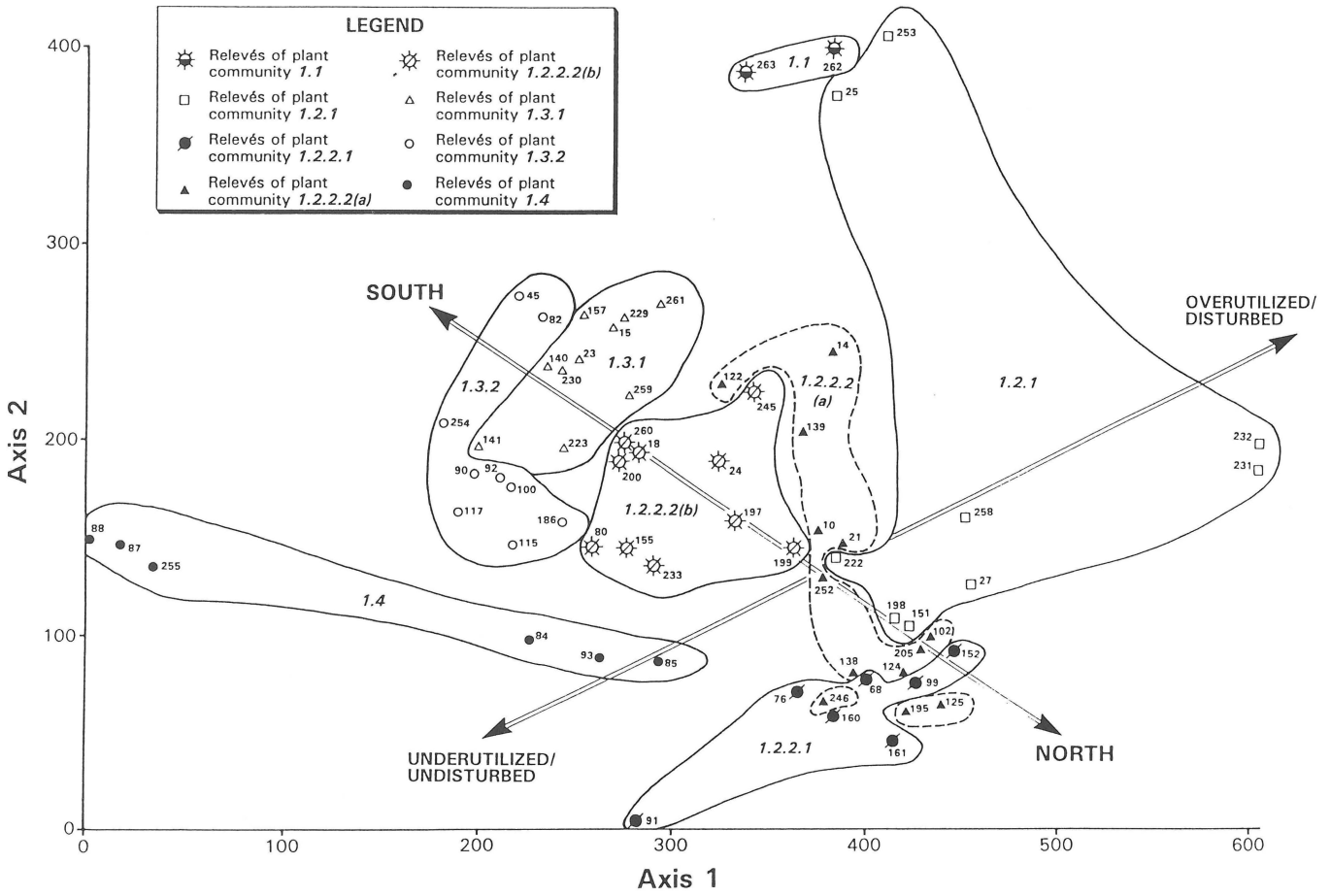

Figure 3 The DCA ordination of the low thicket plant communities of the rocky outcrops of the study area.

conspicuously cliff-like) and a particularly humic A-horizon. Species often encountered in these relevés, but not in the three relevés clustered on the left-hand side, include the graminoids *Hyparrhenia hirta, H. dregeana, Andropogon appendiculatus, Elionurus muticus* and *Cymbopogon plurinodis* and the forb *Salvia repens* (Table 1). The relevés of the left-hand cluster are associated with steeper, more disturbed slopes and huge boulders, often appearing cliff-like. The graminoid *Arundinella nepalensis* is more dominant in these relevés with *Imperata cylindrica* occurring among the rocks lower down the slopes (Table 1).

Concluding remarks

The strong presence of woody species on many rocky outcrops in the climatic climax Grassland Biome is ascribed to the shelter and favourable moisture regimes associated with high percentages of surface and sub-surface rock. Rainfall accumulation between rocks, concomitant with the volume of the soil profile occupied by sub-surface rocks, results in deeper rainfall infiltration, favouring species with a taproot system. Equally important may be the protection of seedlings and young plants from frost and fire afforded by the rocks. Furthermore, the warmer micro-climate of the northerly facing slopes probably is conducive to the establishment of woody species.

The presented delineation of the plant communities and associated habitats should be used as the basis for future management and conservation of these areas. Long-term species, plant community and ecosystem conservation will only be assured if ecological boundaries are incorporated first and foremost into land-use planning and management.

The restricted distribution of the plant communities associated with rocky outcrops, together with the species richness recorded, makes it imperative that conservation of these plant communities receives high priority.

Although the specific plant communities recorded and described here are notably different, there are distinct similarities between the species and plant communities encountered on the rooky outcrops of this study area and those found on rocky outcrops of adjacent areas (see Eckhardt *et al.* 1993; Fuls *et al.* 1992; Breytenbach 1991).

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